POWER PLANT EFFICIENCY

Testimony of Shahab Khoshmashrab

SUMMARY OF CONCLUSIONS

The project would decrease reliance on fossil fuel, and would increase reliance on renewable energy resources. It would not create significant adverse effects on fossil fuel energy supplies or resources, would not require additional sources of energy supply, and would not consume fossil fuel energy in a wasteful of inefficient manner. No efficiency standards apply to this project. Staff therefore concludes that this project would present no significant adverse impacts on fossil fuel energy resources.

HHSEGS would occupy approximately 6.2 acres per MW of power output, a figure higher than that of some other solar power technologies.

INTRODUCTION

HHSEGS would generate 500 megawatts (MW) (nominal net output) of electricity. HHSEGS would be a solar thermal power plant in Inyo County, California. It would use solar energy to generate most of its electrical capacity. The project would use proprietary solar thermal power tower technology[1] to produce electrical power using steam turbine generators fed from solar steam generators.

The land that would be occupied by this project for power generation and power plant operation would be approximately 3,097 acres. Fossil fuel, in the form of natural gas, would be used to reduce startup time, to maintain system temperatures overnight, and for limited power augmentation when solar energy diminishes or during transient cloudy conditions.

METHODOLOGY AND THRESHOLDS FOR DETERMINING ENVIRONMENTAL CONSEQUENCES

Fossil fuel use efficiency

One of the responsibilities of the California Energy Commission (Energy Commission) is to make findings on whether the energy use by a power plant, including the proposed HHSEGS project, would result in significant adverse impacts on the environment, as defined in the California Environmental Quality Act (CEQA). If the Energy Commission finds that HHSEGS's energy consumption creates a significant adverse impact, it must further determine if feasible mitigation measures could eliminate or minimize that impact. In this analysis, staff addresses the inefficient and unnecessary consumption of energy.

[1] http://www.brightsourceenergy.com/technology

In order to develop the Energy Commission's findings and conclusions, this analysis examines:

- whether the facility would likely present any adverse impacts upon energy resources; and if so,
- whether these adverse impacts are significant; and if so,
- whether feasible mitigation measures or alternatives could eliminate those adverse impacts or reduce them to a level of insignificance.

Solar land use efficiency

Solar thermal power plants typically consume much less fossil fuel (usually in the form of natural gas) than other types of nonrenewable thermal power plants. Therefore, common measures of power plant efficiency such as those described above are less meaningful. Solar power plants do occupy vast tracts of land, so, the focus for these types of facilities shifts from fuel efficiency to land use efficiency. To analyze the land use efficiency of a solar facility staff utilizes the following approach.

Solar thermal power plants convert the sun's energy into electricity in three basic steps:

- Mirrors and/or collectors capture the sun's rays.
- This solar energy is converted into heat.
- This heat is converted into electricity, typically in a heat engine such as a steam turbine generator or a Stirling Engine-powered generator.

The effectiveness of each of these steps depends on the specific technology employed; the product of these three steps determines the power plant's overall solar efficiency. The greater the project's solar efficiency, the less land the plant must occupy to produce a given power output.

The most significant environmental impacts caused by solar power plants result from occupying large expanses of land. The extent of these impacts is likely in direct proportion to the number of acres affected. For this reason, staff evaluates the land use efficiency of proposed solar power plant projects. This efficiency is expressed in terms of power produced, or MW per acre, and in terms of energy produced, or MW-hours (MWh) per acre-year. Specifically:

- Power-based solar land use efficiency is calculated by dividing the maximum net power output in MW by the total number of acres impacted by the power plant, not including offsite facilities (i.e.; offsite pipelines, roads, transmission lines and substations).
- Energy-based solar land use efficiency is calculated by dividing the annual net electrical energy production in MWh per year by the total number of acres impacted by the power plant. Since different solar technologies consume differing quantities of natural gas for morning warm-up, cloudy weather output leveling, and maintaining system temperatures overnight (and some consume no gas at all), the effect of the quantities of natural gas consumed by each power plant is accounted for in this calculation. Specifically, gas consumption is backed out by reducing the plant's net

energy output by the amount of energy that could have been produced by consuming the project's annual gas consumption in a modern combined cycle power plant. (See **Efficiency Appendix A**). This reduced energy output is then divided by acres impacted.

PROPOSED PROJECT

SETTING AND EXISTING CONDITIONS

The applicant proposes to build and operate HHSEGS, a solar thermal power plant producing a total of 500 MW (nominal net output). The project would consist of two solar fields (Solar Plant 1 and Solar Plant 2) using concentrating solar thermal tower technology, and would be located in Inyo County, California. Each solar field would consist of a large circular field of mirrors (called "heliostats") that reflect the sun's energy onto a central receiver tower to produce electrical power using a steam turbine generator fed from solar steam generators. The land that would be occupied by this project would be approximately 3,097 acres. Each solar field would consist of arrays of approximately 85,000 heliostats, one solar receiver steam generator (SRSG), one steam turbine generator, one auxiliary boiler, one nighttime preservation boiler and an air-cooled condenser (HHSG 2011a, AFC §§ 1.1, 2.1, 2.2.5; CH2 2012p, Boiler Optimization Plan, p. 101).

The project's power cycle would be based on a steam cycle (also known as the Rankine cycle) (HHSG 2011a, AFC §§ 2.1, 2.2.1). Solar energy is reflected by the heliostats onto the SRSG where the energy heats water into superheated steam. The steam is then routed via the main steam pipe to the steam turbine generator where the steam's energy is converted to electrical energy by the expansion of steam through the turbine.

Each solar plant would utilize two natural gas-fired boilers; one for overnight preservation (to maintain system temperatures overnight); and one to reduce startup time and to augment power production when solar energy diminishes or during transient cloudy conditions. On an annual basis, heat from natural gas would be limited by fuel use and other conditions to roughly 5 percent of the heat from the sun (HHSG 2011a, AFC Appendix Table 5.1B-13R, Amended April 2012).

ASSESSMENT OF IMPACTS AND DISCUSSION OF MITIGATION

CEQA Guidelines state that the environmental analysis "…shall describe feasible measures which could minimize significant adverse impacts, including where relevant, inefficient and unnecessary consumption of energy" (Cal. Code Regs., tit. 14, § 15126.4(a)(1)). Appendix F of the Guidelines further suggests consideration of such factors as the project's energy requirements and energy use efficiency; its effects on local and regional energy supplies and energy resources; its requirements for additional energy supply capacity; its compliance with existing energy standards; and any alternatives that could reduce wasteful, inefficient and unnecessary consumption of energy (Cal. Code Regs., tit. 14, § 15000 et seq., Appendix F).

The inefficient and unnecessary consumption of energy, in the form of non-renewable fuels such as natural gas and oil, constitutes an adverse environmental impact. An adverse impact can be considered significant if it results in:

- adverse effects on local and regional energy supplies and energy resources;
- a requirement for additional energy supply capacity;
- noncompliance with existing energy standards; or
- the wasteful, inefficient and unnecessary consumption of fuel or energy.

Project Energy Requirements and Energy Use Efficiency

HHSEGS would consume some fossil fuel for power generation. It would consume fossil fuel to reduce startup time, for overnight preservation, and to augment power production when solar energy diminishes or during transient cloudy conditions.

The annual natural gas consumption would be limited to approximately 746,400 million British thermal units (MMBtu) (AFC § 5.1, Amended April 2012, Table 5.1-13R); equal to roughly 5 percent of the heat input from the sun. Thus, most of the project's produced electricity would come from the sun (a renewable source of energy). Compared to a typical fossil fuel-fired power plant of equal capacity (500 MW net), and compared to the relatively considerable resources of fossil fuel in California (see below in **Adverse Effects on Energy Supplies and Resources**), this rate of natural gas consumption is not significant. Natural gas is a relatively efficient form of fossil fuel.

The project's steam cycle efficiency, based on the solar heat input alone which would be the bulk of the project's energy input on an annual basis, is expected to be approximately 44 percent (HHSG 2011a, AFC Figure 2.2-3, enthalpy across the heat exchanger versus net electrical output). This efficiency figure compares favorably with a conventional boiler.

Therefore, staff considers the impact of the project's fuel consumption on energy supplies and energy efficiency to be less than significant.

Adverse Effects on Energy Supplies and Resources

The applicant has described its source of natural gas for the project. A 12-inch-diamter natural gas supply pipeline for HHSEGS would connect to an existing Kern River Gas Transmission (KRGT) pipeline approximately 32.4 miles southeast of the project site. A tap station on the main KRGT transmission pipeline would be installed at that interconnection point just north of Goodsprings in Clark County, Nevada. (CH2 2012ee) A gas metering station would be required at the interconnection point to measure and record gas volumes from the KRGT metering station (HHSG 2011a, AFC §§ 2.1, 2.2.3). KRGT's natural gas supply system draws from extensive supplies originating in the Rocky Mountains. It draws from the oil and gas producing fields of southwestern Wyoming through Utah and Nevada to the San Joaquin Valley near Bakersfield, California, and is capable of delivering the required amount of natural gas for this project. Staff believes that there would be adequate natural gas supply and pipeline capacity to meet the project's needs (2012 California Gas Report[2]).

Additional Energy Supply Requirements

Because KRGT's natural gas supply system is extensive and readily available as explained above (in **Adverse Effects on Energy Supplies and Resources**), staff believes there would be no likelihood that HHSEGS would require the development of additional energy supply capacity (see above in **Adverse Effects on Energy Supplies and Resources**).

Compliance with Energy Standards

No standards apply to the efficiency of HHSEGS or other non-cogeneration projects.

Alternatives to Reduce Wasteful, Inefficient, and Unnecessary Energy Consumption

Staff typically evaluates project alternatives to determine if alternatives exist that could reduce the project's fuel use. The evaluation of alternatives to the project (that could reduce wasteful, inefficient, or unnecessary energy consumption) requires the examination of the project's energy consumption.

Efficiency of Alternatives to the Project

Please see the project alternatives discussed below and the alternative technologies discussions in the **Alternatives** section of this FSA for further information.

Alternative Generating Technologies

Alternative generating technologies for HHSEGS are considered in the AFC (HHSG 2011a, AFC § 6.7). For purposes of this analysis, natural gas, oil, coal, nuclear, geothermal, biomass, hydroelectric, wind, solar photovoltaic (PV), and parabolic trough solar thermal technologies were all considered. Because HHSEGS's consumption of fossil fuel for power production and other uses would be limited to roughly 5 percent of the total energy input from the sun, staff believes that the HHSEGS project would not constitute a significant adverse impact on fossil fuel energy resources compared to feasible alternatives.

The solar insolation falling on the earth's surface can be regarded as an energy resource. Since this energy is inexhaustible, its consumption does not present the concerns inherent in fossil fuel consumption. What is of concern, however, is the extent of land area required to capture this solar energy and convert it to electricity. Setting aside many acres of land for solar power generation removes it from alternative power generation uses. Specifically, from a power plant efficiency viewpoint, the concern is related to the quantities of land that would be unavailable, at least for the life of a project, to be utilized for alternative generating technologies. Thus, in comparing a solar plant's technology to alternative technologies, staff considers the land area that would

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[2] http://www.socalgas.com/regulatory/documents/cgr/2012%20CGR_Final.pdf

be unavailable, and not only the land that would be graded and leveled. For example, for a solar power plant, whether or not the space between two rows of mirrors/panels would be leveled and/or graded, that area of land would not be available (at least for the operating life of the project) for the utilization of alternative power generation technologies.

For the purpose of comparing a project to alternative generating technologies, staff focuses more on land use efficiency rather than energy-based efficiency because land use efficiency is less subject to variations, and thus, more suitable for comparison. Energy-based efficiency can vary, sometimes significantly, throughout the life of the project depending on factors such as the need for dispatchability.

Thus, staff's comparison of the power plant efficiency of HHSEGS to other technologies focuses on land use efficiency rather than some other metric.

To assess HHSEGS's land use efficiency staff compares the land use efficiency of the solar projects licensed by, or currently before, the Energy Commission, to HHSEGS. This comparison helps determine a range of viable land-use efficiencies and where HHSEGS falls within that range.

At the time of this FSA's publication, there are 11 solar power plant projects that are either going through the Energy Commission siting process, or have been previously licensed by the Energy Commission for construction and operation[3]. These projects' power and energy output, and the extent of the land occupied by each, are summarized in **Efficiency Table 1**, below. The solar land use efficiency for a typical natural gas-fired combined cycle power plant is shown only for comparison.

HHSEGS would produce power at the rate of 500 MW net, and would generate energy at the rate of 1,432,000 MWh per year, while occupying 3,097 acres (HHSG 2011a, AFC §§ 1.1, 1.2.1, Appendix Table 5.1B-13R). Accordingly, staff calculates power-based and energy-based land use efficiencies thus:

<u>Power-based efficiency</u>: 500 MW ÷ 3,097 acres = **0.16 MW/acre** or **6.2 acres/MW**

<u>Energy-based efficiency</u>: 1,432,000 MWh/year ÷ 3,097 acres = **463 MWh/acre-year**

As seen in **Efficiency Table 1**, HHSEGS, employing the power tower technology would be less efficient in the use of land than the Beacon Solar Energy Project, which as licensed would have used the linear parabolic trough technology. HHSEGS would be slightly more efficient than Genesis Solar Energy Project, which also uses the linear parabolic trough technology. Also, HHSEGS would be more efficient in the use of land than the Ivanpah SEGS project -- which employs the same proprietary technology as HHSEGS -- and the Calico Solar and Imperial Valley Solar projects, which as licensed would have employed the Stirling Engine technology. Based on information regarding several solar PV (photovoltaic) projects, the expected average occupied land per MW of

[3] http://www.energy.ca.gov/siting/solar/index.html

output is approximately 7.0 acres/MW (see the **Alternatives** section of this FSA for the source of this figure). Compared to 6.2 acres/MW for HHSEGS, PV is less land-use efficient.

On an energy-based efficiency basis, HHSEGS would generate 463 MWh/acre-year; this compares favorably to all other solar projects listed in **Efficiency Table 1** (2^{nd} column from the left).

Alternatives to Reduce Solar Land Use Impacts

Building and operating a natural gas-fired combined cycle power plant would yield much greater land use efficiency than any solar power plant; see **Efficiency Table 1**. However, this would not achieve the basic project objective, to generate electricity from the renewable energy of the sun and would not further the state's renewable energy development goals

Efficiency Table 1 — Solar Land Use Efficiency

Project	Generating Capacity (MW net)	Footprint (Acres)	Annual Energy Production (MWh net)	Annual Fuel Consumption (MMBtu LHV)	Land Use Efficiency (Power-Based) (MW/acre)	Land Use Efficiency (Energy – Based) (MWh/acre-year)	
						Total	Solar Only[1]
HHSEGS (11-AFC-2)	**500**	**3,096**	**1,432,000**	**746,400**	**0.16**	**463**	**424**
Rio Mesa (11-AFC-4)	500	3,805	1,424,600	746,355	0.13	**374**	**343**
Genesis Solar (09-AFC-8)	250	1,800	600,000	60,000	0.14	333	329
Ridgecrest Solar (09-AFC-8)	250	1,440	500,000	44,818	0.17	347	343
Beacon Solar (08-AFC-2)	250	1,321	600,000	36,000	0.19	454	450
Ivanpah SEGS (07-AFC-5)	400	3,744	960,000	432,432	0.11	256	238
Calico Solar (08-AFC-13)	850	8,200	1,840,000	0	0.11	224	224
Imperial Valley Solar (08-AFC-5)	750	6,500	1,620,000	0	0.12	249	249
Solar Millenium (Blythe) (09-AFC-6)	1000	5,950	2,100,000	172,272	0.17	353	349
Solar Millenium (Palen) (09-AFC-7)	500	2970	1,000,000	89,636	0.17	337	332

Abengoa Solar (09-AFC-5C)	250	1684	630,000	94,280	0.15	374	366
Rice Solar (09-AFC-10)	150	1,410	450,000	0	0.11	319	319
Avenal Energy (08-AFC-1)[2]	600	25	3,023,388	24,792,786	24.0	120,936	N/A

[1] Net energy output is reduced by natural gas-fired combined cycle proxy energy output; see **Efficiency Appendix A**.

[2] Example natural gas-fired combined cycle plan

In summary, building a solar thermal power plant employing a different technology than the power tower technology would not considerably improve land use efficiency. Thus, staff believes the technology selected for HHSEGS is reasonable.

Alternative Heat Rejection System

The applicant proposes to employ a dry cooling system (air-cooled condensers) as the means for rejecting power cycle heat from the steam turbines (HHSG 2011a, AFC §§ 2.5.1, 2.5.5.2). An alternative heat rejection system would utilize evaporative cooling towers.

The local climate in the project area is characterized by high temperatures and low relative humidity (low wet-bulb temperature). In low temperatures and high relative humidity (low dry-bulb temperature), the air-cooled condenser performs relatively efficiently compared to the evaporative tower. However, at the project area (low wet-bulb temperature and high dry-bulb temperature) the air-cooled condenser performance is relatively poor compared to that of an evaporative cooling tower. Furthermore, the performance of the heat rejection system affects the performance of the steam turbine, impacting turbine efficiency. However, to conserve water in the project site's desert environment, the applicant proposes to employ dry cooling. Even though evaporative cooling could offer greater efficiency, staff believes the applicant's selection of dry cooling is a reasonable tradeoff, as it would prevent potentially greater significant environmental impacts that could result from the consumption of larger quantities of water that would be required for wet cooling.

CUMULATIVE IMPACT ANALYSIS

There are no nearby power plant projects or other projects consuming large amounts of fossil fuel that hold the potential for cumulative energy consumption impacts when aggregated with the project, because the amount of fuel to be consumed by HHSEGS would be insignificant compared to the considerable resources of fossil fuel, including natural gas, in California.

Staff believes that the construction and operation of the project would not create indirect impacts (in the form of additional fuel consumption) that would not have otherwise occurred without this project. Because HHSEGS would consume significantly less fossil fuel than a typical fossil fuel-fired power plant, it should compete favorably in the California power market and replace older fossil fuel burning power plants. The project would therefore cause a positive impact on the cumulative amount of fossil fuel consumed for power generation.

COMPLIANCE WITH LORS

No federal, state, or local/county laws, ordinances, regulations, and standards (LORS) apply to the efficiency of this project.

NOTEWORTHY PUBLIC BENEFITS

HHSEGS would employ an advanced solar thermal technology. Solar energy is renewable and unlimited. The project would have a less than significant adverse impact on nonrenewable energy resources. Consequently, the project would help in reducing California's dependence on fossil fuel-fired power plants.

PROPOSED CONDITIONS OF CERTIFICATION/MITIGATION MEASURES

No conditions of certification are proposed.

FINDINGS

1. HHSEGS would provide approximately 500 MW (net output) of electrical power, using solar energy to generate most of its capacity and using natural gas auxiliary boilers to maintain steam seals and other system temperatures, reduce startup time, and provide limited power augmentation.

2. HHSEGS is likely to experience an average steam cycle efficiency of 44 percent, which is favorable when compared to the 35 to 40 percent steam efficiency for modern steam turbines.

3. The project would burn natural gas at a nominal rate of approximately 746,400 MMBtus per year. Compared to the project's expected overall production rate and compared to a typical fossil fuel-fired power plant of equal capacity, the amount of fossil fuel consumption is less than significant.

4. The impact of the project's fuel consumption on energy supplies and energy efficiency is less than significant.

5. HHSEGS would not require the development of new fuel supply resources.

6. None of the alternative generating technologies is superior to the proposed project at meeting the project objective of using a renewable source of energy in an efficient and reliable manner.

7. The project would decrease reliance on fossil fuel and would increase reliance on renewable energy resources. Consequently, the project would help in reducing California's dependence on fossil fuel-fired power plants.

8. The project would occupy approximately 6.2 acres per MW of power output, a figure higher than some other solar power technologies. On an energy-based efficiency basis, HHSEGS would generate 463 MWh/acre-year; this compares favorably to all other solar projects listed in **Efficiency Table 1** (2^{nd} column from the left).

9. No nearby power plant projects or other projects consuming large amounts of fossil fuel hold the potential for cumulative energy consumption impacts when aggregated with the project.

10. No Federal, State, or local laws, ordinances, regulations, or standards apply to the efficiency of this project.

CONCLUSIONS

Compared to the project's expected overall production rate of approximately 1,432,000 MWh net on an average annual basis, and compared to a typical fossil fuel-fired power plant of equal capacity, the amount of the annual power production from fossil fuel is not significant; HHSEGS would use solar energy to generate most of its electricity.

The project would decrease reliance on fossil fuel, and would increase reliance on renewable energy resources. It would not create significant adverse effects on energy supplies or resources, would not require additional sources of energy supply, and would not consume energy in a wasteful or inefficient manner. No energy standards apply to this project.

No cumulative impacts on energy resources are likely.

HHSEGS would occupy approximately 6.2 acres per MW of power output, a figure less than that of some other solar power technologies. Building a solar power plant employing the power tower technology is reasonable in order to meet the project objective of generating electricity using a renewable source of energy.

Staff therefore concludes that this project would present no significant adverse impacts on energy resources.

REFERENCES

CH2 2012p – CH2MHill/J. Carrier (tn: 64558) Supplemental Data Response, Set 2, Boiler Optimization Plan and Design Change. 04/02/2012

CH2 2012ee– CH2MHill/J. Carrier (tn: 66319) Applicant's PSA Comments, Set 2. 7/23/2012

HHSG 2011a – BrightSource Energy/J. Woolard (tn: 61756) Application for Certification, Volume 1 & 2. 08/5/2011

Efficiency Appendix A
Solar Power Plant Efficiency Calculation
Gas-Fired Proxy

In calculating the efficiency of a solar power plant, it is desired to subtract the effect of natural gas burned for morning startup, cloudy weather augmentation and nighttime preservation. As a proxy, staff has used an average efficiency based on several baseload combined cycle power plant projects that have gone through the Energy Commission's siting process. Baseload combined cycles were chosen because their intended dispatch most nearly mirrors the intended dispatch of solar plants, that is, operate at full load in a position high on the dispatch authority's loading order.

The most recent such projects are:

Colusa Generating Station (06-AFC-9)

Nominal 660 MW 2-on-1 Combined Cycle with GE Frame 7FA CGTs
Air cooled condenser, evaporative inlet air cooling
Efficiency with duct burners on: 666.3 MW @ 52.5% LHV
Efficiency with duct burners off: 519.4 MW @ 55.3% LHV
Efficiency (average of these two): **53.9% LHV**

San Gabriel Generating Station (07-AFC-2)

Nominal 696 MW 2-on-1 Combined Cycle with Siemens 5000F CGTs
Air cooled condenser, evaporative inlet air cooling
Efficiency with duct burners on: 695.8 MW @ 52.1% LHV
Efficiency with duct burners off: 556.9 MW @ 55.1% LHV
Efficiency (average of these two): **53.6% LHV**

KRCD Community Power Plant (07-AFC-7)

Nominal 565 MW 2-on-1 Combined Cycle with GE or Siemens F-class CGTs
Evaporative cooling, evaporative or fogging inlet air cooling
Efficiency with GE CGTs: 497 MW @ 54.6% LHV
Efficiency with Siemens CGTs: 565 MW @ 56.1% LHV
Efficiency (average of these two): **55.4% LHV**

Avenal Energy (08-AFC-1)

Nominal 600 MW 2-on-1 Combined Cycle with GE Frame 7FA CGTs
Air cooled condenser, inlet air chillers
Efficiency with duct burners on: 600.0 MW @ 50.5% LHV
Efficiency with duct burners off: 506.5 MW @ 53.4% LHV
Efficiency (average of these two): **52.0% LHV**

Average of these four power plants: **53.7% LHV**

The annual fuel consumption in MMBtu/year, converted to MWh/year at 53.7% energy conversion efficiency, and then, subtracted from the total MWh/year (solar + fuel), results in the total MWh/year from only the solar energy input. This number is then divided by the number of acres, which results in the energy-based efficiency (last column in **Efficiency Table 1**).

EFFICIENCY

List of Comment Letters

		Efficiency Comments?
1	Inyo County	
2	Bureau of Land Management	
3	National Park Service	
4	The Nature Conservancy	
5	Amargosa Conservancy	
6	Basin & Range Watch	
7	Pahrump Paiute Tribe	
8	Richard Arnold, Pahrump Piahute Tribe	
9	Big Pine Tribe of Owens Valley	
10	Intervenor Cindy MacDonald	
11	Intervener Center for Biological Diversity	
12	Intervener, Old Spanish Trail Association	
13	Applicant, BrightSource Energy, Inc.	X

Comment #	DATE	COMMENT TOPIC	RESPONSE
13	**July 23, 2012**	**Applicant, BrightSource Energy**	
13.2		References to HHSEGS occupying 6.5 acres/MW.	Staff has revised this figure to account for subtraction of 180 acres of temporary laydown area from the total project footprint; the new figure for HHSEGS is 6.2 acres/MW. Also please see responses to Applicant Comments 13.50 and 13.62.
13.3		Additional explanation to further describe "the effect" in subsection entitled "Solar Land Use Efficiency", 2nd set of bullets, 2nd bullet.	This phrase is described in the PSA in the sentence immediately following the sentence containing this phrase. However, to further describe this, staff has revised this paragraph in the **FSA**. Also see the text at the end of **Efficiency Appendix A**.

13.4		Add, to the last sentence under "Adverse Effects on Energy Supplies and Resources", a citation to CEC Natural Gas Assessment.	Staff has included the correct citation in the **FSA**.
13.5		Add to the statement in "Additional Energy Supply Requirements", a citation to CEC Natural Gas Assessment.	Staff does not believe it is necessary to repeat the citation. The current sentence refers the reader to the sub-section under "Adverse Effects on Energy Supplies and Resources", where the citation is included.
13.6		in subsection "Alternative Generating Technologies" additional metrics need to be taken into account. PV may destroy all habitant, while concentrating solar power may preserve some habitat value.	Please see the response to Comment 13.7. This paragraph has been updated to further explain the reasoning behind the staff's method of analysis for alternative technologies as related to power plant efficiency. From a power plant efficiency viewpoint, the concern is related to the quantities of land that would be unavailable for the life of the project. Such a land area, whether disturbed or not, would not be available, at least for the life of the project, for the utilization of alternative generation technologies.

13.7		Why is land use efficiency the only metric being focused on? What about other metrics like energy-based efficiency, water use, or graded and leveled land area?	From a power plant efficiency viewpoint, the concern is related to the quantities of land that would be unavailable, at least for the life of a project, to be utilized for alternative generating technologies, because setting aside the land area for solar power generation removes it from alternative power generation uses. Thus, in comparing a project's technology to alternative technologies, staff considers the land area that would be unavailable for the life of the project, and not only the land that would be graded and/or leveled. For example, for a solar power plant, whether or not the space between two rows of mirrors/panels would be leveled and/or graded, that area of land would not be available (at least for the operating life of the project) for alternative power generation technologies. Staff has compared this project with other projects using the energy-based efficiency (in terms of MWh/year) (see **Efficiency Table 1** and the text). However the focus remains on land use efficiency, because it's less subject to variations and thus more suitable for comparison. Energy-based efficiency can vary, sometimes significantly, throughout the life of the project depending on factors such the need for dispatchability. Staff has recognized the benefits of this project in regards to water use in subsection "Alternative Heat Rejection System", but does not believe water use should be the focus of the power plant efficiency analysis.
13.8		Add a column to Efficiency Table 1 for acres/MW to coincide with comparison described in text.	Staff does not believe this is necessary, as the column showing the efficiency figures in terms of numerical ratios is self-explanatory in displaying the degree of the efficiency of HHSEGS as compared to the other projects.
13.9		revise values in Efficiency Table 1 to reflect the project being downsized to 500 MW.	Staff has done this.

13.10		In "Alternative Heat Rejection System", the comparison of tradeoff would be more meaningful if it were quantified.	Staff's goal from writing this sentence is simply to acknowledge that there is a tradeoff; staff does not believe the tradeoff needs to be quantified in this section. Furthermore, in order to precisely quantify the loss in efficiency, an engineering evaluation for this project would need to be undertaken, which staff believes is unnecessary. Also, the values for efficiency losses and reduction in water consumption are two different metrics and quantifying them for the purpose of making comparison is not very meaningful.
13.11		Conclusions, 4th paragraph, 1st sentence: correct "incude" to include".	There is no such a typo.